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SCIENCE

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*THE IMPORTANCE AND THE PROMISE IN THE STUDY OF THE DOMESTIC ANIMALS.**

IT is believed that for the advancement of science, no better service can be rendered by those of considerable experience as teachers and investigators than to point out to their younger brethren lines of study and research which are, on the one hand, important, and on the other promising of results. I have, therefore, selected for the subject of this address before the section of zoology a plea for the study of the domestic animals. The young zoologist may rightfully ask the grounds for studying this heterogeneous, greatly modified series of animals. In the first place it must be confessed that for the animal kingdom as a whole it appeals mainly to a single one of the twelve phyla in the animal series given by Parker and Haswell—that is, to the vertebrates. The other eleven phyla—that is, the whole of the invertebrates except the arthropoda—are ignored. I wish to express very clearly and emphatically at the outset that the plea will not be made because the domestic animals seem to me alone worthy of study by zoologists, or that they are in all cases the best possible representatives of their group. It is most earnestly believed, however, that in the whole range of zoology no forms offer a greater reward for the study of the problems of life, especially in the higher groups, than the domestic animals. The importance of the study cannot be overestimated from a purely scientific standpoint, and certainly if the prosperity, happiness and advancement of the human race are put in the count the subject is of transcendent importance.

* Address of the Vice-President and Chairman of Section F, Zoology, of the American Association for the Advancement of Science, Columbus, August 21, 1899.

A glance at the tabular arrangement of the domestic animals will show where they are situated in the animal kingdom. In the great group of Invertebrates the two domesticated species—the Honey-Bee and the Silk-Worm—may be properly compared to minute islands in a great ocean. Among the Vertebrates, on the other hand, the domestic forms are represented in two of the six classes, viz.: in the Birds and Mammals, and where represented are among the most prominent and important members of the various orders:

DOMESTIC INVERTEBRATES.

The Honey-Bee (*Apis mellifica*).
The Silk-Worm (*Bombyx mori*).

DOMESTIC VERTEBRATES.

Class Aves—Birds.

1. **Natatores** { Goose (*Anser cinereus*). Duck (*Anas boschas*). Swan (*Cygnus gibbus*).
2. GRALLATORES—Waders (no domestic forms).
3. **Gallinaceæ** { Hen (*Gallus domesticus*). Turkey (*Meleagris americana*). Peacock (*Pavo cristatus*).
4. **Columbinæ**—Pigeon (*Columba livia*).
5. SCANSORES — Climbers (Parrots, woodpeckers, etc.). (No domestic forms.)
6. **Passeres**—Canary Bird (*Serinus canarius*).
7. RAPTORES—(Formerly the Falcon was in a sense domesticated).
8. **Cursores**—Ostrich (*Struthio camelus*).

Class—Mammalia.

(A) MONOTREMATA (Forms which lay eggs).
(B) MARSUPIALIA (Forms without true placenta).

ORDERS OF PLACENTAL MAMMALS.

1. EDENTATA—Armadillo, sloth, etc.
2. CETACEA—Whale, porpoise, etc.
3. SIRENIA—Manatee and Dugong.
4. **Ungulata** { Horse (*Equus caballus*). Ass (*Equus asinus*). Pig (*Sus scrofa*). Camels { *Camelus dromedarius.* *Camelus bactrianus.* Sheep (*Ovis aries*). Goat (*Capra hircus*). Ox (*Bos taurus*). Elephant (*Elephas indicus*).
5. **Carnivora** { Cat (*Felis domestica*). Dog (*Canis familiaris*).
6. **Rodentia** { Rabbit (*Lepus cuniculus*). Guinea Pig (*Cavia cobaya*).
7. INSECTIVORA—Mole, hedgehog, etc.
8. CHEIROPTERA—Bats.
9. PRIMATES { Monkeys and apes. Man (*Homo sapiens*).

NOTE—In the table of birds the ordinal arrangement is that of Claus. It will be noted that five of the eight orders of birds have domesticated representatives. Among placental mammals three of the nine orders are represented, the order Ungulata containing the larger number and the most important representatives. A few forms in addition to those named in the tables have been, at some time, more or less completely domesticated.

With the personnel of the subject for discussion thus fairly before us, what has been, what is, and what is likely to be the influence of these forms in the rise and progress of knowledge in the broad field of zoology? Or more specifically, (1) What has been and what is likely to be the influence of the study of the domestic animals upon the doctrine of the evolution of organic forms? (2) What has the study of them contributed in comparative anatomy, embryology and physiology? (3) What has been the contribution in hygiene and preventive medicine? (4) And, finally, what should be their influence in theories of heredity and sociology?

If we would realize the value of the Doctrine of Evolution, let us imagine for an instant that this doctrine of 'orderly change' were eliminated from the knowledge of men!

To turn the zoologist back to the old notions of special and independent creation for each species or group of animals, would be like leaving the astronomer only the sun-god, and the angels to direct the planetary movements. No, it is now next to impossible to conceive of zoology struggling to comprehend the animal kingdom without this guiding principle. If similarity of form, color, structure and stages in embryology, function and even diseases are mere coincidences without further meaning, then, indeed, from a scientific standpoint, one

might as well spend his life and thought on Chinese puzzles as upon zoology. But that there is meaning and inspiration in the study of zoology requires no argument from me in this company, for on the altars of of this section still burns the sacred fire kindled by our absent members—Agassiz, Leidy, Cope, Allen, Marsh and a host of others who now 'see as they are seen, and know as they are known.' It is only for me to endeavor to point out some ways in which that study may be most productive.

If the doctrine of evolution has so illuminated the way, given meaning and point to the work which it never had before, it is pertinent to ask, to what are we indebted for the general belief in this doctrine? No better answer can be given than in the words of Darwin himself in the introduction to the 'Origin of Species:' "It is, therefore, of the highest importance to gain a clear insight into the means of modification and coadaptation. At the commencement of my observations it seemed to me probable that a careful study of domesticated animals and cultivated plants would offer the best chance of making out this obscure problem. Nor have I been disappointed; in this and in all other perplexing cases I have invariably found that our knowledge, imperfect though it be, of variation under domestication, afforded the best and safest clue. I may venture to express my conviction of the high value of such studies, although they have been very commonly neglected by naturalists." In a work published on this side of the Atlantic, the author, Professor L. H. Bailey, a member of our old Section of Biology, boldly faces those who, still doubting, say: "perform this miracle of changing one species into another before our eyes, and we will believe;" and says: "If species are not original entities in nature, then it is useless to quarrel over the origination of them by means of experiment. All we want to know, as a proof of evolution, is whether plants and animals can be profoundly modified by different conditions, and if these modifications tend to persist. Every man before me knows, as a matter of common observation and practice, that this is true of plants. He knows that varieties with the most marked features are passing before him like a panorama. He knows that nearly every plant which has been long cultivated has become so profoundly and irrevocably modified that people are disputing as to what wild species it came from. Consider that we cannot certainly identify the original species of the apple, peach, plum, cherry, orange, lemon, wine grape, sweetpotato, Indian corn, melon, bean, pumpkin, wheat, chrysanthemum, and nearly or quite a hundred other common cultivated plants. It is immaterial whether they are called species or varieties. They are new forms. Some of them are so distinct that they have been made the types of genera. Here is an experiment to prove that evolution is true, worked out upon a scale and with a definiteness of detail which the boldest experimenter could not hope to attain, were he to live a thousand years. The horticulturist is one of the very few men whose distinct business and profession is evolution. He, of all other men, has the experimental proof that species come and go." * * * Almost or quite as strong a statement might be made concerning domestic animals, as stock breeders and fanciers well know. But the more cautious may say, and have said: "This is the work of man's hands; man who ate of the forbidden tree and became like unto the gods, a lesser creator." Well, here again, ages before coming under man's dominion one of the domestic forms gave the final demonstration.

Those who have read the masterly argument of Huxley in the American addresses on evolution, the address of Marsh before the old natural history section of this

Association in 1877, and the address of Osborn before this section in 1893, know well the story. Starting with the generalized, five-toed forms of the basal Eocene in our own country, passing through many modifications and lateral experiments as they may be called, the five-toed form gradually became the four, three, and finally the one-toed modern horse, with its allies, the ass and the zebra. Thus long before the Coast Range was brought forth, while still the eternal hills were young, the primitive horses disported themselves in vast multitudes in our Western Territories; and it is believed that from this contient they passed to Asia, Africa and Europe, only to come back in these latter days to this so-called New World after making the circuit of the entire earth.

Among living forms perhaps no creature aided more in carrying conviction to the mind of Dawin himself, and to countless other people, than the common domestic pigeon. For most of the domestic animals it is usual to bring in a hypothetical, fossil type, so widely have the living forms departed from any living wild types, and so true to the domestic types do the offspring hold; but with the pigeon it is not uncommon that reversions to the parent form occur, and even in the most modified forms reversions occur, so that there is substantial agreement that the parent stock is the wild rock pigeon (*Columba livia*). That there should be reversions in some forms is astounding, for even the number of vertebræ has become changed by domestition.

If, then, this study of domesticated and cultivated forms has thrown so much light upon this great subject of evolution as the method of nature, is there not promise of rich return for future study? And there is need of future study, for only a beginning has yet been made in this great field.

Let us now turn from Evolution to discuss for a few moments the help which the domestic forms have given to Anatomy, Embryology and Physiology.

If one asks of what animals the structure is known in the greatest detail it must undoubtedly be answered that the structure of man has been most thoroughly explored, then come the domestic animals, especially the horse, dog, cat and rabbit. Much of this work was done before the doctrine of evolution illuminated the way and gave meaning to rudiments or vestiges and to homologies. Still it must be said, in truth, that the older zoologists, with a rare insight, discussed large questions of homology, and recognized at bottom the real relationship of many different forms. It was, however, only the philosophical and far-sighted few who did so. The majority of anatomical work was done for its purely practical bearing on medicine and surgery. It thus happened that human anatomy exerted a powerful influence, indeed, so powerful that names were carried over into the invertebrates, for parts which could hardly, by the greatest stretch of imagination, be homologous with the structures in man from which they were named. If there was any relationship it was of function or analogy rather than that fundamental kinship expressed by homology. Thus the legs of a horse and a spider are for the same general purpose. They are analogous, not homologous organs. Therefore, in many cases in the older morphological work one should not be deceived by supposing that there was any real insight into the phylogenetic relationship of the two forms whose parts were similarly named. While there has been a great tendency to designate parts alike which have only a fancied or analogous relationship, there has been a more harmful tendency to ignore real relationships. Only purely practical ends have been too often in view, and the real kinship of forms as little known as cared about.

What is urgently needed at the present time in comparative anatomy, especially that relating to the domestic animals, is a thorough revision in the light of this last half of the 19th century; then the student, whether especially trained in human, veterinary or comparative anatomy, could pass from form to form and far more easily correlate truly homologous parts, because they would bear the same designations; and he would thus be led to see and appreciate the true kinship, although at first sight there might appear to be only unlikeness.

If any one cannot see the force of what has been said, or does not feel any lack in the present conditions, let him think of the different joints in the limbs of man, horse, dog, chicken and honey bee; or let him ask some one who knows the animals well, but is untrained in advanced anatomy. I believe that such an experience would convince any open-minded inquirer that like designations for homologous parts are desirable; and, secondly, he would be filled with increased admiration for the view of organic nature which points out the significance of a real likeness in what appeared in the beginning so utterly diverse. Here then is work which stands ready for the ablest zoologists.

In Embryology and Physiology the domestic animals have always furnished the greatest amount of information, as one can satisfy himself by consulting any treatise upon these subjects, although 'Human Embryology,' 'Human Physiology' may be printed on the title page. Who did not get his start in embryology by studying the development of the chick, the dog, cat, rabbit or guinea pig? And in physiology students are almost equally dependent on the dog and rabbit. What is known in these fields is but a drop in the bucket, and as the domestic animals have contributed the greater part of that drop, so will they be called upon to fill the bucket to the brim. And what a splendid outlook there is at the present time. New discoveries in physics, like the X-rays, make possible advances in physiology. Perfection of technique in microscopy makes advance in embryology possible. Contemplate the opportunity and the promise for a moment. There is not a single treatise in any language which deals adequately with the embryology of the domestic animals, and the only one in English, the only one usually studied by the veterinary student, is hopelessly bad and antiquated. If one glances at the tables showing the zoological position of the different domestic animals he must be impressed with their wide distribution in the animal kingdom and their representative character. What an opportunity is here for work in comparative embryology! It is coming to be felt that the embryology of the present day is very inadequate in that, while it professedly deals with the entire development of the individual, it really devotes its main energy to the earliest stages and to the very beginnings of the organs. The complete ontogeny of the individual must go further than this and trace the development from the ovum through all the life stages to old age and death. It is only among the domesticated forms, in the higher groups at least, that abundant material under complete control, is at command, without very great expense. Abundant material, with full knowledge concerning it, will be required for satisfactory monographs in the future.

For students, material in great amount at a merely nominal cost, and without sacrificing animals especially for the purpose, may be had at every large abattoir; and every village slaughter house wastes more than enough embryological material every year to supply the aspiring young zoologists in its precincts. That this material is being utilized is evident from the admirable papers upon em-

bryological subjects and from the laboratory announcements of Harvard, Johns Hopkins and many other centers for investigation and sound embryological instruction.

It was intimated above that the pressing need of zoology to-day is complete knowledge of some typical forms, such, for example, as are represented by the domestic animals in the avian and mammalian classes. This thorough knowledge is needed rather than more of the bits and patches from the entire animal kingdom. It is certainly true that morphological knowledge at the present day is too much like a crazy quilt. This every investigator finds to his cost when he wishes to carry a research beyond the most elementary stages. What is needed, then, is concentration—complete knowledge, so far as possible, of each form investigated; and this knowledge must compass the entire life cycle. As also stated above, embryology has, and perhaps properly, concerned itself largely with the beginnings of the organisms and their organs. But in so doing the later but no less important changes have been left almost untouched. Ontogenetic development after birth is of the profoundest importance from all biological standpoints. In some ways a knowledge of how the newborn becomes an adult is certainly of profounder interest than how an egg becomes a new-born animal. A few years ago the agricultural experiment stations, especially those of Wisconsin and New York, wished to answer, so far as possible, the question of how to obtain the best nutrition and growth to render animals most satisfactory as food and thus, also, the most profitable in the market.

There arose questions concerning the changes in muscle, if any, in passing from youth to maturity and from maturity to old age; from a condition of leanness to fatness. Here were some very pertinent questions which only a biologist could answer, but at that time many of the questions were enshrouded in darkness. But during the present year several investigations bearing upon these points have been published. Every one knows that the muscles increase in size as well as in strength in a growing animal, and also that they increase in size and strength in an adult if properly exercised. But who would have been prepared to expect that in this increase in power and size of the whole muscle the individual fibers of which it is composed would actually decrease in number? This brings us to the fundamental question of the mechanism and the structural changes by which youth and maturity are merged into old age and decay? If you will read the suggestive address of Dr. Minot given at the Indianapolis meeting in 1890, and the papers of Hodge on the changes in nerve cells from childhood to senility, you will gain a notion of the work to be done upon the post-embryonal ontogeny, and the rewards to be gained by the faithful, clear-brained investigator.

I cannot leave this part of the subject without reminding you again of the brilliant part the paleontology of the horse has played in zoological science, and to express the belief that its embryology, when thoroughly worked out, will play an equally brilliant one. At present this embryology is known only in fragments. Why should there not arise in this boundless western world, in the land where the earliest horses appeared, some embryologist who, with the cheap and abundant material, should work out this problem with completeness? Next to man himself there is probably no animal in which the civilized world is more profoundly interested. To trace in the growing embryo not only its own life history, but to gather as many and clear glimpses as possible of its race history, would, indeed, be an inspiration. Enough

is already known to make one sure that the field is worth working and that the harvest is certain. Almost as much might be said for some of the other domestic animals. And why should not some of this splendid work be done in America? This was the original home of the horse, of representatives of all the groups of domesticated animals, and every summer brings from its boundless treasures ever new and more marvelous forms. I believe that the time will come—indeed, that it is at hand—when zoological science, yes all science in America, will go forward with the giant strides which have already characterized her inventive and industrial history.

So far this address has been practically limited to the higher vertebrates, but I would not remain wholly silent upon the great phyla of invertebrates. The honey-bee and the silkworm should not be passed by without a word. Their history, like that of most of the domestic animals, is shrouded in darkness, but they are still with us, calling forth from each generation renewed interest and admiration. They, too, offer problems for the biologist, and deserve his attention. For example, take that great question of apparent voluntary parthenogenesis with the bees. What is the mechanism by which fertilized eggs become queens or workers and unfertilized eggs become only drones? Is this very general belief really true? If true what are the differences in the course of development in the eggs in the two cases? Then in Physiology what a multitude of problems the bees propound? Why will a special form of food cause an egg to develop into a queen instead of a worker? How can the workers change honey into beeswax? How can a mere blind pouch serve the purposes of digestion and excretion in the larva? For answering all these questions and many others the honey-bee is admirably adapted. One can keep the swarm constantly under his eye, and he can control, so far as necessary, the actions of the bees; there is abundance of material which may be had at all stages of development. Indeed, with the hundreds of thousands, perhaps millions, of insect species yet to discover and describe, and all these questions of structure, function, embryology, transformation, histolysis and redevelopment to answer, it looks as if the entomologist would not be compelled to sit down and sigh for new worlds to conquer for some time yet. And if I may be allowed to carry over my convictions from the vertebrates to the invertebrates, I believe that zoology would be far more advanced if a million or two species of insects were left undescribed and the enthusiasm and devotion of the entomologists—and no class of zoologists are more enthusiastic and devoted—were directed toward the elucidation of the entire life cycles of a few typical forms, and the structure, function and embryology of these were worked out as completely as modern knowledge and method would allow. Then there would be some standards of comparison to facilitate the work on the infinite number of forms still uninvestigated. From the mongraphs on the embryology and morphology of insects which have appeared during the last few years one cannot help feeling that this fascinating field will soon claim a multitude of students, and that none need go away empty-handed.

In Preventive Medicine and Hygiene the domestic animals have, as in so many other fields, served as the basis for study and investigation. To appreciate their importance one has but to recall the fact that at the close of the last century Jenner's application of cowpox as a protection against smallpox has led to an almost complete expulsion of this once dreaded scourge from civilized lands. Or to refer to the memorable investigations of Pasteur begun in 1866 for the amelioration of the condi-

tion of the silk industry of France. He saw and pointed out, with the greatest clearness, the importance of cleanliness, fresh air and good food for the avoidance of degeneration and disease in the silkworms. Are not fresh air, cleanliness and good food the very foundation stones of hygiene for all animal forms? In the silkworms, also, Pasteur found causes for disease in the microscopic organisms which infested their bodies, and in some cases at least this cause appeared to pass from one generation to the next through the eggs. What this study of Pasteur upon the diseases of silkworms, upon anthrax in the domestic mammals upon fermentation, did for surgery is thus expressed by Lister, the recognized father of antiseptic surgery, at the jubilee celebration of Pasteur: "Truly there does not exist in the entire world any individual to whom the medical sciences owe more than they do to you. Your researches on fermentation have thrown a powerful beam which has lighted the baleful darkness of surgery, and has transformed the treatment of wounds from a matter of uncertain and too often disastrous empiricism into a scientific art of sure beneficence. Thanks to you, surgery has undergone a complete revolution, which has deprived it of its terrors and has extended, almost without limit, its efficacious power."

In our own and in other countries what untold loss has come from 'Texas Cattle Fever?' The working-out of the biological relations of that disease, it seems to me, is one of the most brilliant pieces of scientific investigation which has illuminated this truly luminous end of the 19th century. With all the knowledge accumulated since Pasteur's investigations on the silkworm diseases to serve as guides and to give suggestions, it took one of the foremost pathologists which our country has produced (Dr. Theobald Smith) three years to bring the investigation to a demonstration. And little wonder! For instead of the previously known simple relations of microbes to disease, the way was round about and involved two generations of animals and two species. Furthermore, the germ of the disease was not a bacterium or fungus, easy to cultivate on artificial media, but one of the sporozoa for which no artificial culture medium has yet been devised. The story is briefly as follows: Cattle ticks (*Boophilis bovis*) suck the blood of animals in which the Texas-fever germ is present. The germs enter the eggs of the ticks and thus infect the next generation. This new generation of ticks attach themselves to other cattle and introduce into their blood the disease germs which are carried over from a previous generation. And so the mutual infection goes on in a vicious circle from generation to generation. The direct human interest, outside the economic one, which this investigation has is the suggestion and the accumulating proof that malaria in man is transmitted in practically the same manner by mosquitoes. Truly the living hypodermic syringes are to be feared as well as execrated.

Thus hardly a triumph in medicine has been won without substantial aid from the domestic animals, and it is believed by the acutest minds engaged in the great work of ameliorating the sorrows of the world caused by preventable disease and premature death that we are now only on the threshold of discovery. Is not the fact that the discoveries in medicine and hygiene in the past have been so dependent upon the domestic animals sufficient guarantee that future discovery will be likewise dependent upon them; and as human beings are so closely linked with the domestic animals in economics, in hygiene and in promised avoidance of disease, is there not abundant reason why the veterinary profession should be elevated and become a true unit in university life, a close colleague

with the profession of human medicine; and that human medicine in turn should reap even greater good in future by a more thorough appreciation and study of comparative medicine?*

At this time, when the dawn of the 20th century is already in the sky, the biological problem most important to the animals, and to the human race in its aspirations, is the problem of heredity. What is its mechanism, what light does it throw upon the chances for preservation from degradation, and for elevation to exalted manhood? Organic evolution has shown in the clearest manner that 'descent with modification,' in order to meet the requirements of the environment, does not, by any means, signify in all cases what is commonly meant by the term progress. Consider the mental and physical condition of parasites. They have descended literally, and with the profoundest modifications. Look at the serpents and the partly limbless forms of the ocean. In their descent they progressed toward fitness for their environment, fitness to make the most and best of the life they have to lead; but this is not the modification desired in human descent. The Utopia for human society is where there is abundant food for all, congenial labor for all, education and amusement for all, every one to work out in its fullness his own individuality and at the same time serve the common weal. What lessons do the domestic animals give upon this? That 'like produces like' is a generalization believed in by every one, and sufficiently supported by every-day observation. Equally true and general is the statement that 'like produces unlike'—that is, no offspring is exactly like its parents, and no two offspring are exact duplicates. While the race type is persistent, individual modifications are infinite. In this likeness and still unlikeness between offspring and parent is the hope and the despair of mankind. The hope because every horticulturist, every stock breeder and every parent hopes that the offspring will be unlike, but that the unlikeness will be an improvement. The despair because unlikeness is just as liable to take the trend of the undesirable qualities and intensify them. With the lower animals the undesirable modifications may be eliminated, must be eliminated, or the race will deteriorate. In the human family the problem is equally plain, but infinitely more difficult of execution. How can the brood of criminals be avoided and the sturdy and right-minded possess the earth?

If one would see how social theories have worked themselves out successfully the domestic animals again furnish models, models in which theory is no longer theory, but fact under which thousands of generations have lived, flourished and passed away. The most perfect states are found among the social insects, foremost of which are to be mentioned the honey-bee. This society, which man has had under domestication so many thousand years that the beginning has been forgotten, has won the admiration of the world, and poets and philosophers have immortalized it with their words. What could appear more perfect? Each member of the society is apparently free, and each labors for the common good. Truly it seems an ideal state, but to attain this ideal state queens must kill their sisters or be killed by them; thousands must be relegated to ceaseless toil, and kings exist but for a day. This perfect state consists only of a queen-mother and thousands of sexless slaves. All exist, not

* For further discussion of the relations between human and comparative medicine, see for Comparative Medicine, Dr. James Law's address at the inauguration of the New York State Veterinary College, September 24, 1896.—*Veterinary Magazine*, September, 1896. For Human Medicine, see Dr. Charles S. Minot's Yale University Medical Commencement Address, June 29, 1899.—SCIENCE, July 7, 1899.

for their own individual pleasure, improvement or happiness, but only for the community. If socialists will study this and other examples of states which have resolutely worked out the social problems to a successful finish they will perhaps get an inkling of how far off is the realization of all Utopias, of even the noble aspirations of our own National Declaration of Independence. Their realization is far off and difficult or impossible because the struggles of individualism are never compatible with perfect socialism. It is not possible to serve both the state and the individual with one's whole power. If there is partial service, as there must be in human society, neither the state nor the individual will have the most perfect development. The parallelogram of forces will give a resultant to be sure, but so far this resultant has proved a tortuous and unsatisfactory line instead of the perfect form of beauty dreamed of by the enthusiasts.*

In this brief review I have tried to show a few ways in which the study of domestic animals has thrown light on the problems confronting mankind in his social ideals, in preventive medicine, in physiology and hygiene, in embryology and comparative anatomy and in the doctrine of the evolution of organic forms. The attempt has been made to show that, with the higher forms at least, that is the forms most closely related to man, and with whose destiny his own economic, hygienic and social relations are most closely interwoven, the domestic animals have in the past and promise in the future to serve the best purpose because of the abundance of the material in quite widely separated groups of animals which long have been and still are under greatly differing conditions and surroundings; and, finally, because this material is plentiful and under control, and thus may be studied throughout the entire life cycle.

If any one is repelled from the study of domestic animals because they have been greatly modified by their so-called artificial surroundings in the company of man, I would remind him that man is also a part of nature, and that the modifications due to his action simply illustrate, in a somewhat definite and determinable degree, the plasticity of the forms under his control, and thus give the clearest and most undeniable proof of the capability of change in response to environment and selection. Furthermore, any wild form chosen for investigation has likewise departed widely from its primitive state, under the stress of changed and changing environment and a selection somewhat different but none the less severe. It is also contended that the knowledge of the environment of these domestic members of the zoological family for so long a time has been of the utmost help to many of the ablest workers, as one can infer from the quotation from Darwin in the earlier part of this address. There has been and still is too great a tendency in biology to study forms remote and inaccessible. This is, perhaps, partly due to the fascination of the unknown and the distant, and the natural depreciation of what is at hand. But study of these supposedly generalized types has proved more or less disappointing. No forms now living are truly primitive and generalized throughout. They may be in parts, but in parts only. The stress of countless ages has compelled them to adjust themselves to their changing environment, to specialize in some directions so far that the clue through them to the truly primitive type is very much tangled or often wholly lost. Indeed, every group is in some features

* The reader who is interested in sociology is advised to read the admirable articles of Mrs. Anna Botsford Comstock on Insect Socialism in *The Chautauquan* for 1898, Nos. 4, 5 and 6; also Shaler's 'Domesticated Animals,' for their influence in civilization.

primitive. Even man himself is one of the best forms to study the limbs upon. As expressed by one of my colleagues (J. H. Comstock) in his papers upon phylogeny, the unraveling of the mysteries of 'descent with modification' in their entirety cannot be worked out in a single form or group; the puzzle must be spelled out part by part, and one group will serve best for one organ and another for another.

As any complete study requires much material at all stages the higher forms must be of the domesticated groups, or wild forms must be practically domesticated for the time being to supply the material.

It may be objected, also, that in the investigation of domesticated forms sordid interests will play too prominent a part. No doubt, to the true scientific man the study of zoology for its own sake, that is for an insight into the fundamental laws of life, is a sufficient incentive and reward. Judging from the past, the study of the domestic animals in any other way than in a scientific spirit and by the scientific method will prove barren, but studied in that spirit and by that method the result has always justified the effort, and has thrown as much, if not more, light upon biological problems than an equally exact study of a wild form.

Therefore, while purely practical ends can never supply the inspiration to true scientific work, still surely no scientific man could feel anything but happiness that his work had in some ways added to the sum of human well being. Perhaps no one has expressed so well the sympathy of a scientific man with his fellow men as Pasteur in the preface to his work on the silkworm diseases: "Although I devoted nearly five consecutive years to the laborious experimental researches which have affected my health, I am glad that I undertook them. * * The results which I have obtained are perhaps less brilliant than those which I might have anticipated from researches pursued in the field of pure science, but I have the satisfaction of having served my country in endeavoring, to the best of my ability, to discover a remedy for great misery. It is to the honor of a scientific man that he values discoveries which at their birth can only obtain the esteem of his equals, far above those which at once conquer the favor of the crowd by the immediate utility of their application; but in the presence of misfortune it is equally an honor to sacrifice everything in the endeavor to relieve it. Perhaps, also, I may have given young investigators the salutary example of lengthy labors bestowed upon a difficult and ungrateful subject."

As a final word, let me summarize this address by saying: However necessary and desirable it may have been in the past that the main energy of zoologists should be employed in the description of new species and in the making of fragmentary observations upon the habits, structure and embryology of a multitude of forms, I firmly believe that necessity or even desirability has long since passed away, and that for the advancement of zoological science the work of surpassing importance confronting us is the thorough investigation of a few forms from the ovum to youth, maturity and old age. And I also firmly believe that, whenever available, the greatest good to science, and thus to mankind, will result from a selection of domesticated forms for these thorough investigations.*

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* If the young zoologist wishes to get a clear notion of the meaning and value of 'species' in modern biology he is recommended to read Dr. Farlow's address in last year's Proceedings; also Dr. D. S. Jordan's 'Kinship of Life' in his 'Footnotes on Evolution,' and Professor Bailey's chapter on 'Experimental Evolution Amongst Plants' in his book on the 'Survival of the Unlike.'